MAVEN observations of substorm-like processes in the Martian magnetosphere

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Mars’ Magnetic Environment

- No global intrinsic field
- Localized crustal magnetic fields
- Strongest sources at 180°E Longitude in southern hemisphere

Connerney et al., *PNAS*, 2005
Martian Magnetosphere

- Induced magnetosphere with localized planetary fields
- IMF direction influences the field structure
- Similar regions to intrinsic magnetospheres with similar processes on different scales
- No ‘Dungey Cycle’

Brain et al. [2015]
MAVEN’s Orbit

Orbit precesses to provide complete coverage

Side View

View from tail
Magnetic Reconnection at Mars

Halekas et al. [2009]
Tail Reconnection: Fast Flows

- Particle acceleration in the tail current sheet
- Downtail speeds of 100 km/s or greater

DiBraccio et al. [2015]
Tail Reconnection: Flux Ropes

Current sheet crossing with embedded flux rope supports magnetic reconnection
Tail Reconnection: Flux Rope Chains

MGS - Eastwood et al. [2012]

 MAVEN - Hara et al. [2017]
Tail Reconnection: Hall Fields

Hall B polarity => Crossing sunward of the X line

trapped e-

Sunward flow enhancement

Harada et al. [2017]
Energy-time Dispersed Electrons

- Falling tones from ~200 eV to ~50 eV
- Electrons PADs show two-sided loss cones

Harada et al. [2016]
Tail Loading and Unloading

**Loading**
- Occurs over intervals of 3-5 min
- IMF drapes over planet and flux builds

**Unloading**
- Occurs over intervals of 2-4 min
- Sudden $|B|$ decrease by factor of 6
- Flux ropes support reconnection
Aurora

Image credit: M. Holstrom/ESA

Schneider et al. [2015]
Discrete Aurora

MEX/SPICAM aurora detection:
• Confined increase in UV brightness
• Emission from vertical crustal field or ‘cusp’ region
• ~130 km altitude

MGS observations:
• Peaked electron distributions
• 400 km altitude on nightside
• Correlated with strong crustal fields

Bertaux et al. [2005]

Brain et al. [2006]
MAVEN observations:

- Rise in auroral brightness correlated with SEP arrival
- 60-100 km altitude

- Coverage obtained over subsequent orbits
- 5 day period

Schneider et al. [2015]
Three solar events occurred on March 1st, 6th, and 8th 2015
Global magnetosphere disruption

Jakosky et al., Science, 2015
Summary

• Mars experiences substorm-like signatures:
  – Magnetic reconnection (hall fields, fast flows, etc.)
  – Flux rope formation
  – Tail Loading/Unloading
  – Aurora
  – Energy-time dispersed electrons
  – Global response to solar events
  – FACs
  – Inverted-Vs

• A global process has yet to be quantified
  – Does one exist?
  – It is possible to find a single definition of a Mars storm?